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G1K 1T
G1N 1D2B 3V5 4C 7Q AGD
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(56) Documents cited
GB 1519698 GB 1447151 GB 1368492
GB 1344222 GB 1336223 US 4573706

(58) Field of search
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H1N
G1N
G1K
Selected US specifications from IPC sub-classes
B60R G01P H01H

(54) Improvements in and relating to vehicle crash sensors

(57) The sensor means 10 detects crashes earlier and discriminates better when mounted at an angle to a horizontal plane passing through the horizontal axis of the vehicle so that it responds to both horizontal and vertical declaration compts. The sensor 10 is preferably of the damped ball-in-tube type Figs. 3 and 4 (not shown) and the angular mounting thereof ranges from 10 to 40 degrees to the horizontal axis of the vehicle, with the forward end of the sensor lower than the rear. The sensor may alternatively be a switch or a mass whose motion cots on electrical strain gauges or piezoelectric crystals, Fig. 5 (not shown). The sensor is preferably mounted away from the steering wheel column, e.g. in the transmission tunnel.

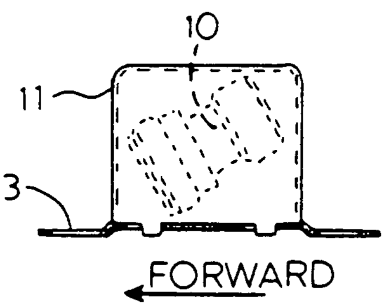

FIG.1

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy

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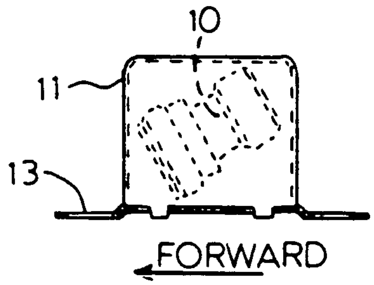
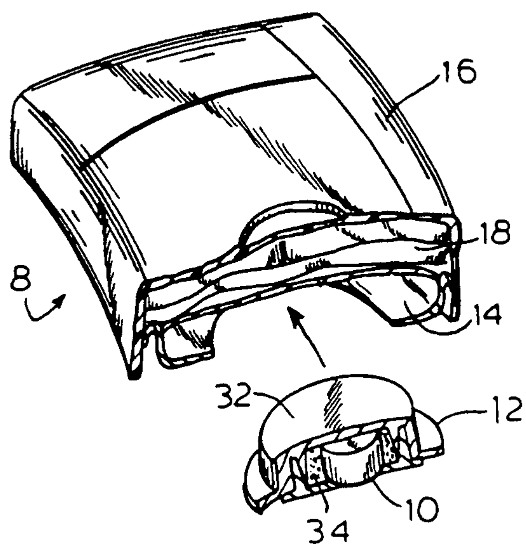


FIG.1

FIG.2



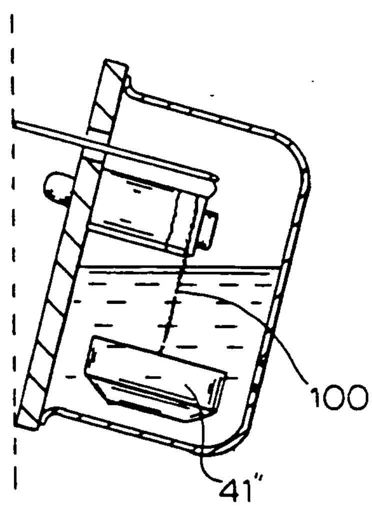


FIG.5

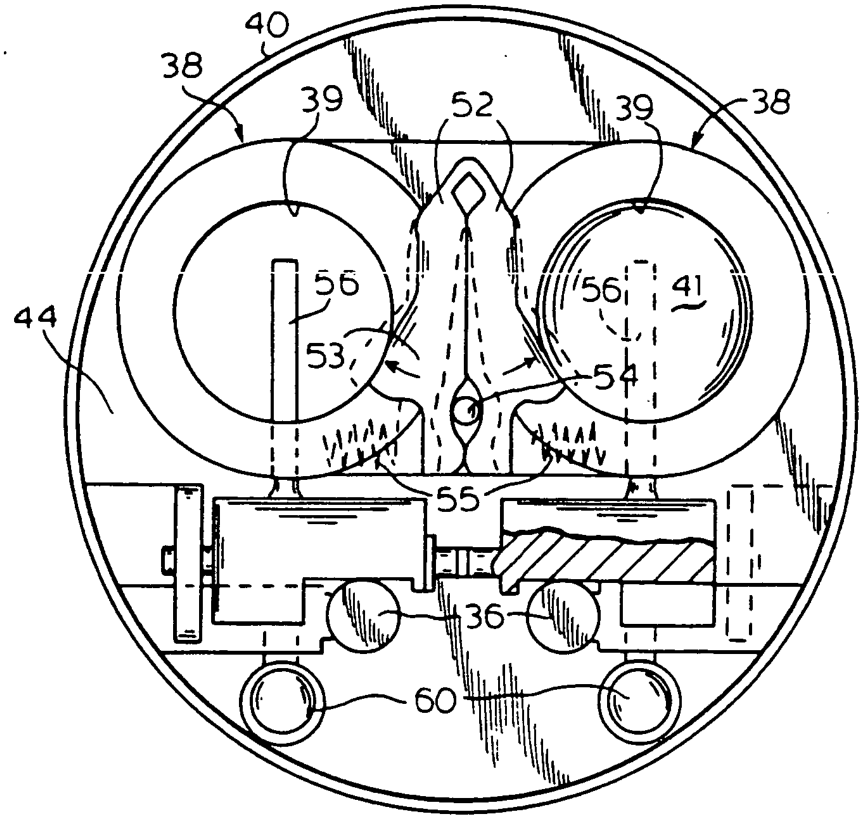

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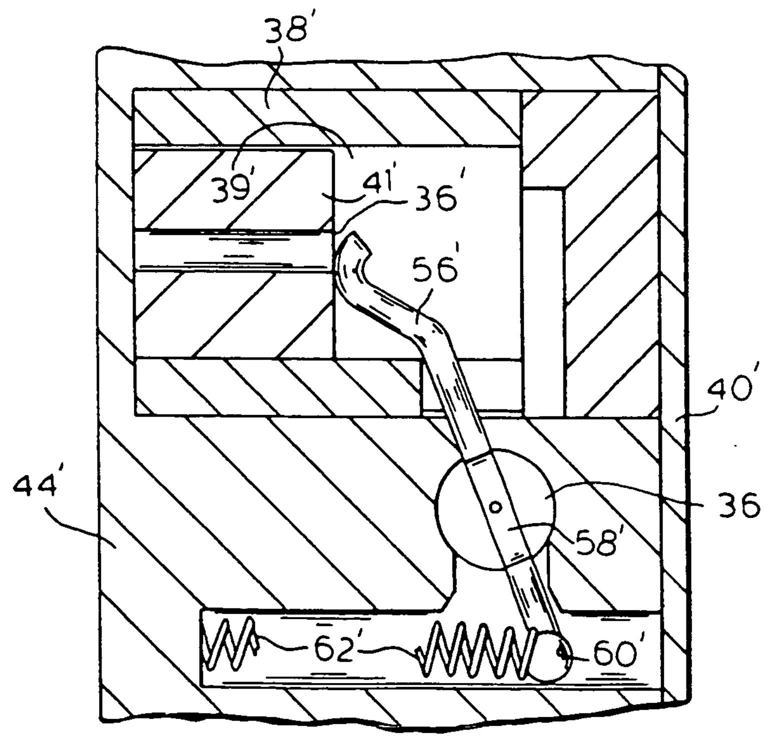
FIG.3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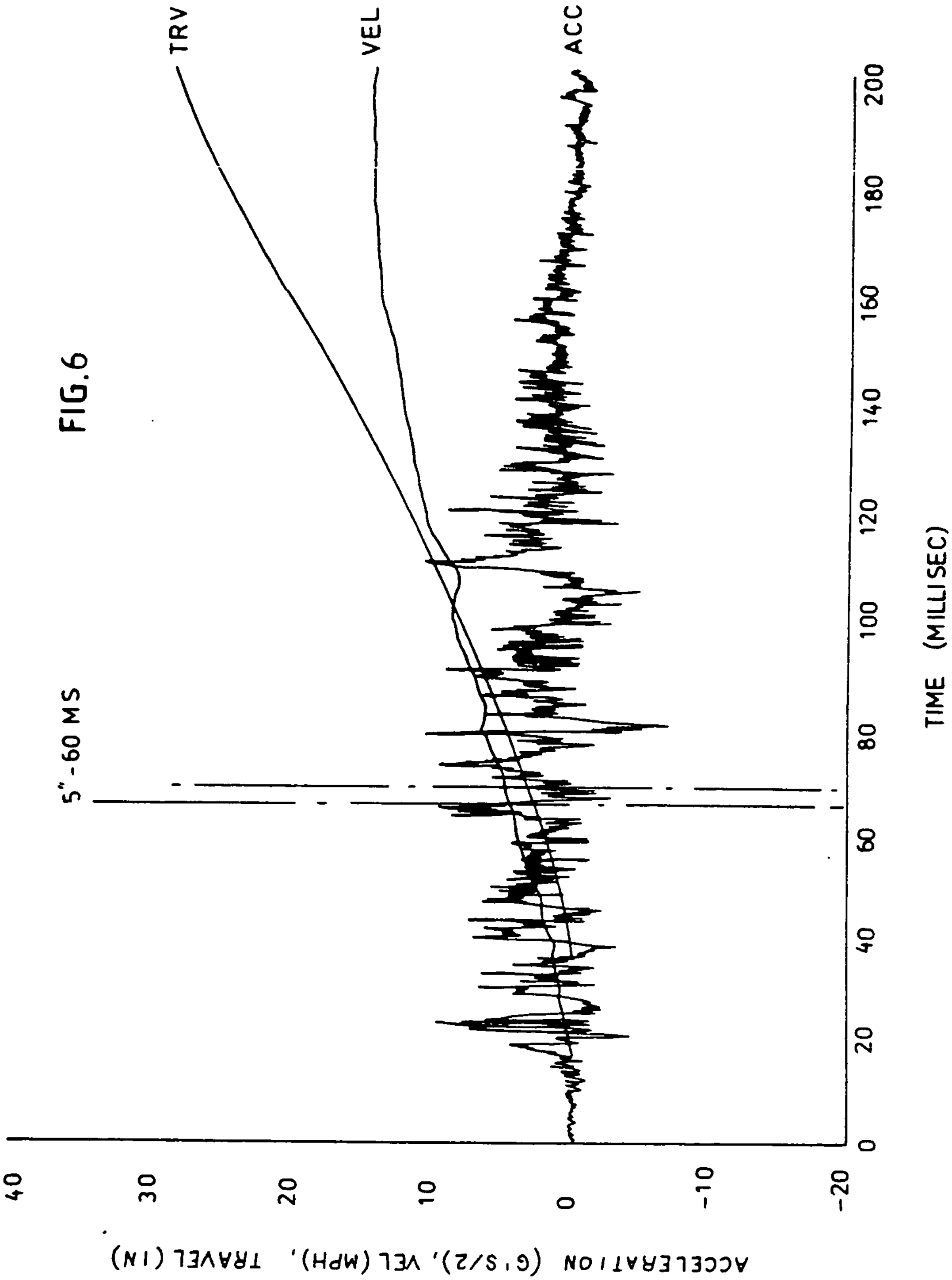
62'
60'

FIG.4

FIG.6



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TIME (MILLISEC)
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ACCELERATION (G'S/2), VEL (MPH), TRAVEL (IN)

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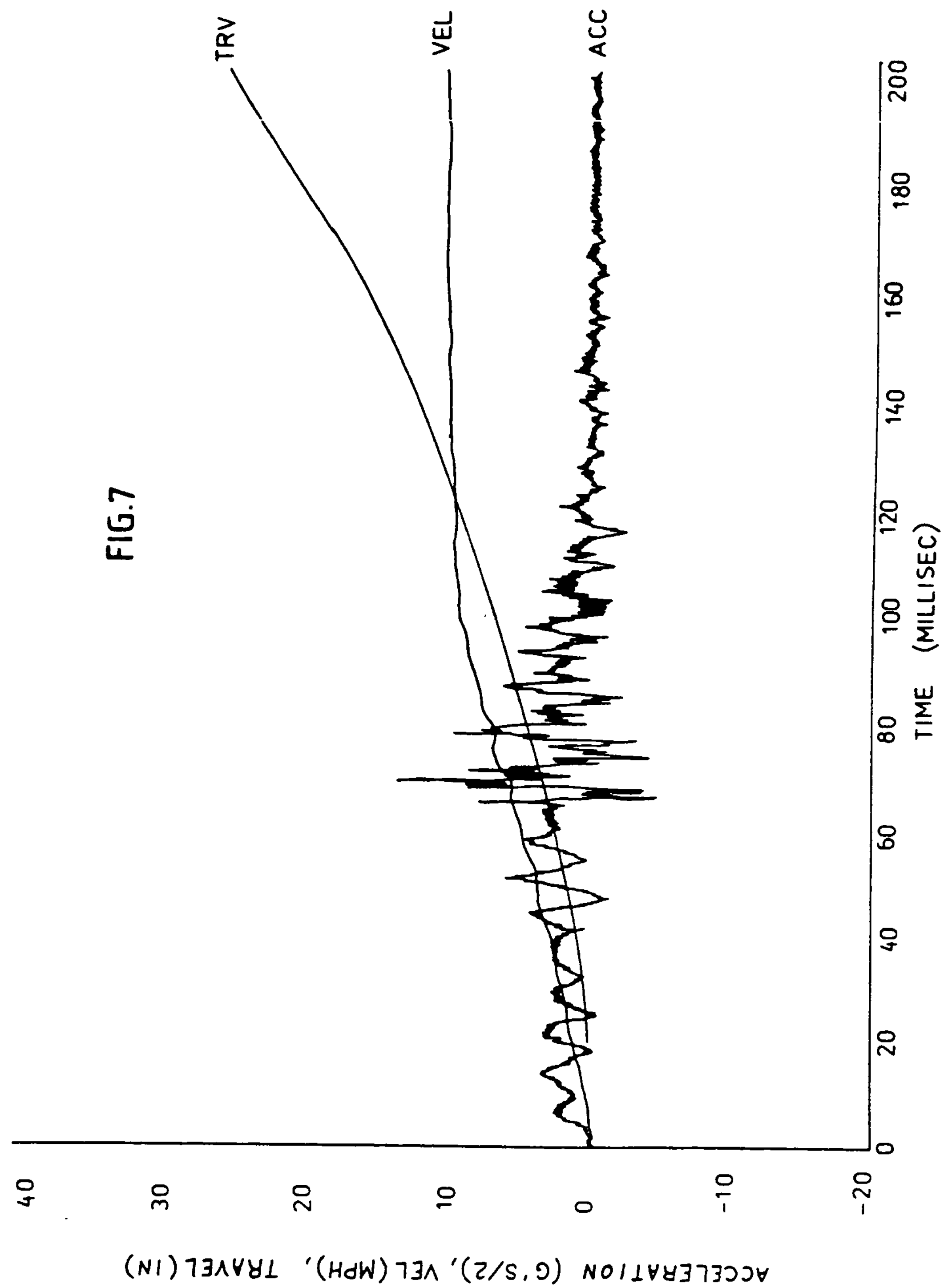
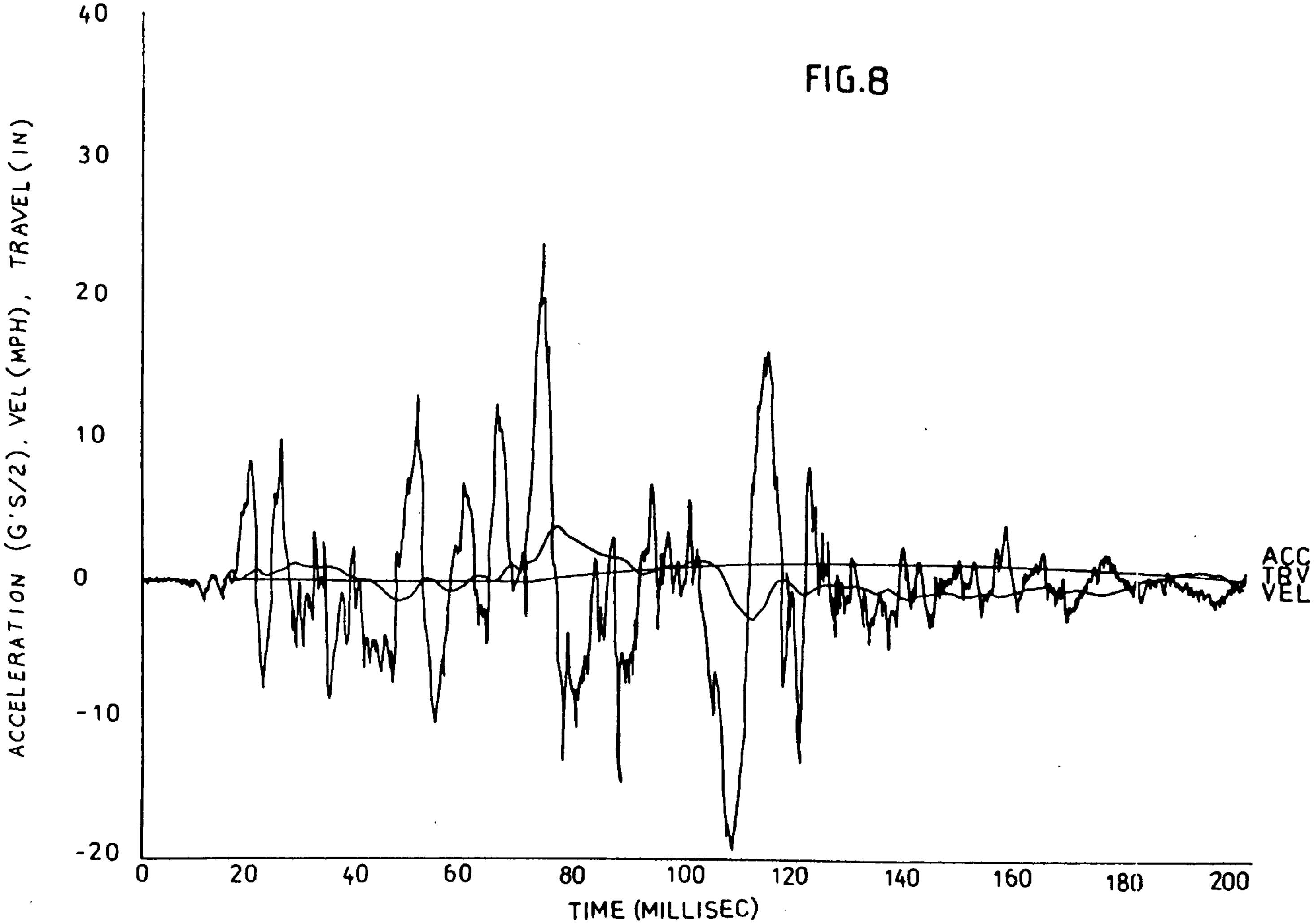


FIG.7

FIG.8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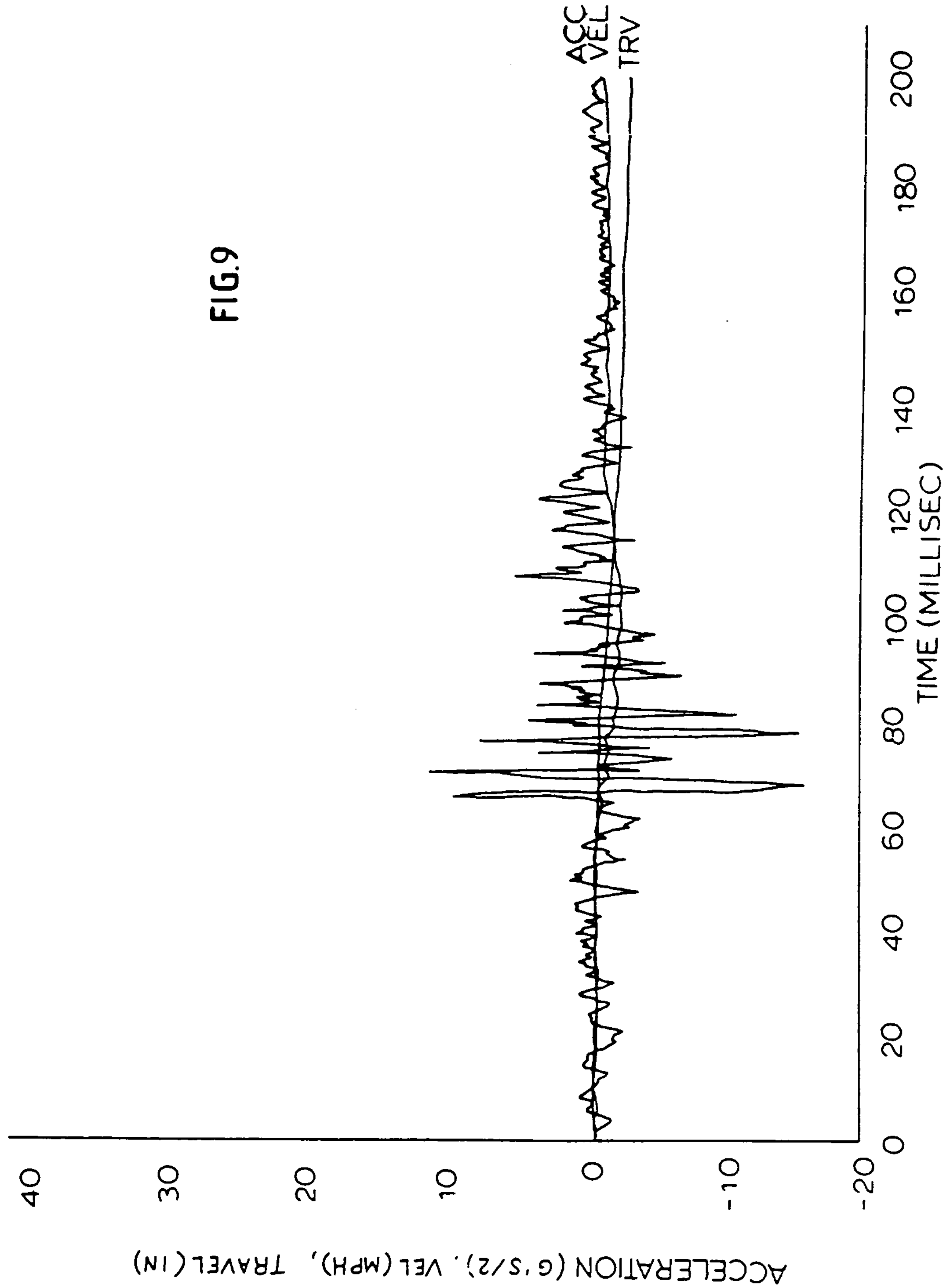
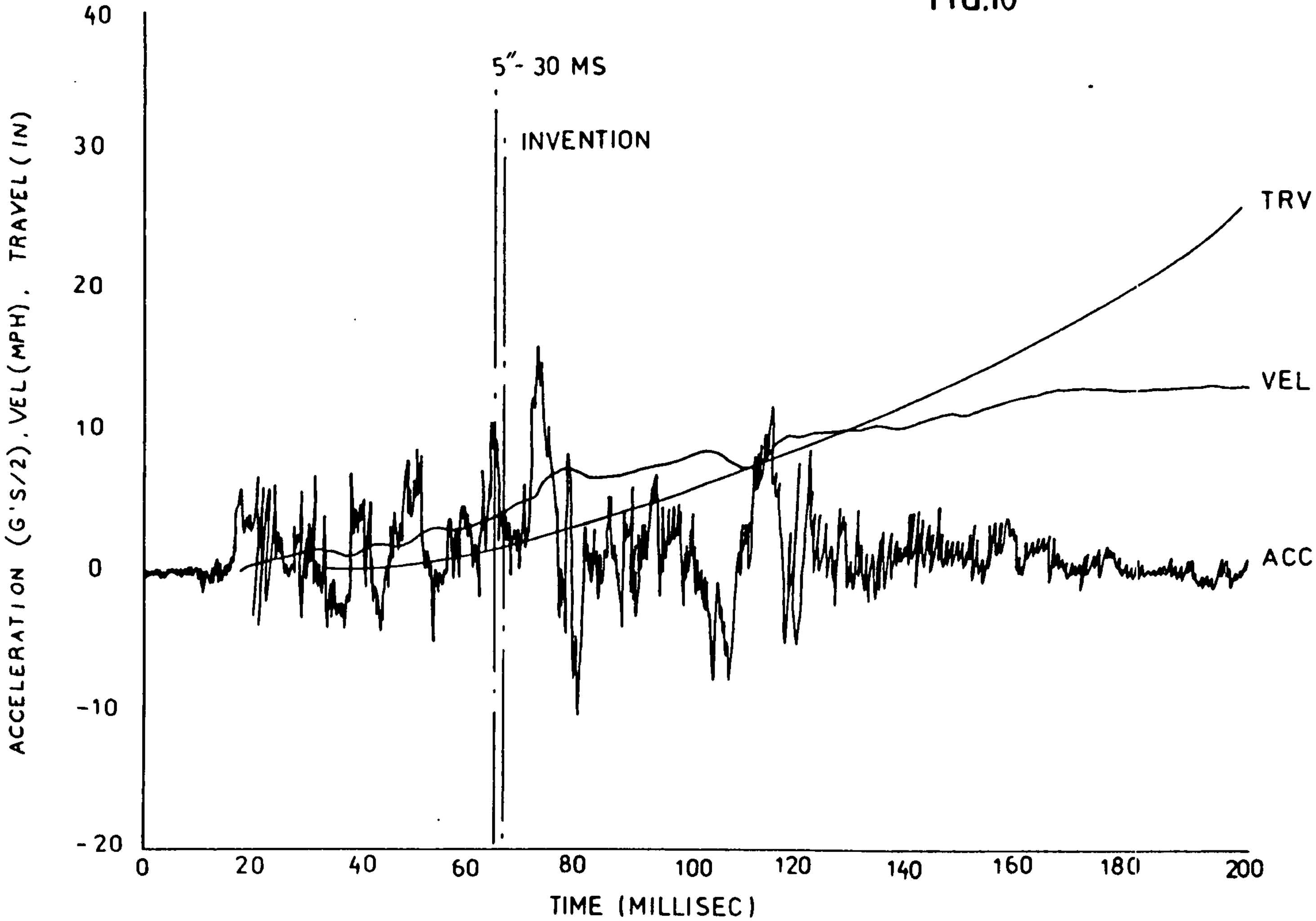


FIG.9

FIG.10



5"- 30 MS
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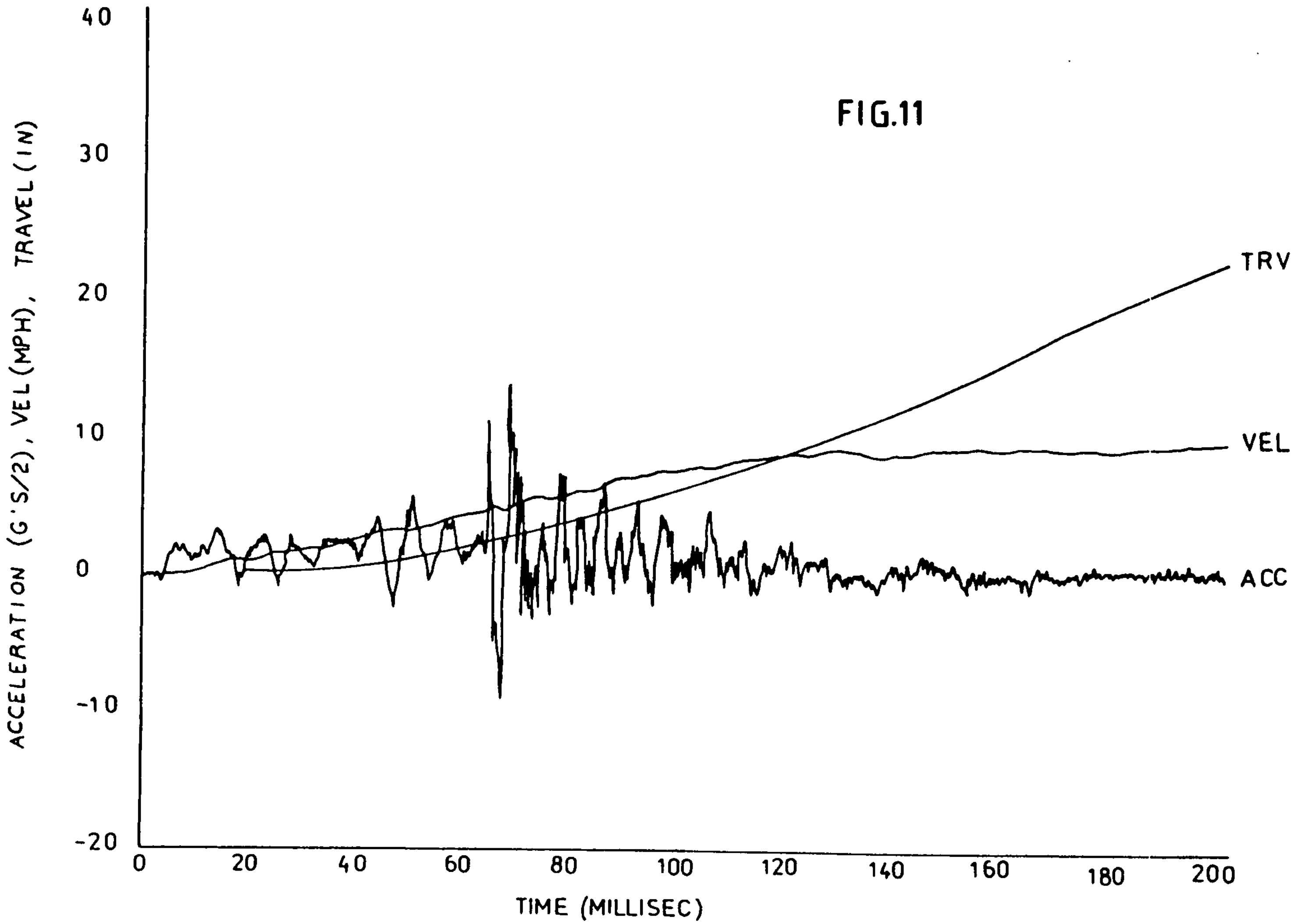
FIG.11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ACCELERATION (G'S/2), VEL (MPH), TRAVEL (IN)

2197373

"Improvements in and relating to vehicle crash sensors"

The invention relates to crash sensors for use in vehicles equipped with airbags. More specifically, the invention relates to the placing of the crash sensors.

The present invention also constitutes an improvement over our United States Patents Nos. 4,284,863, 4,329,549, 4,573,706 and 4,580,810, the disclosures of which are incorporated herein by reference.

U.S. Patents Nos. 4,284,863 and 4,329,549 relate to damped ball-in-tube crash sensor designs.

In U.S. Patent No. 4,573,706, there is disclosed and claimed a mechanical sensor with a low bias for mounting within a vehicle passenger compartment which is operable without electric power for igniting the pyrotechnic elements of an airbag safety restraint system, where the sensor comprises a sensor train which includes a sensing mass, a spring bias, a firing pin, a primer, and means responsive to sustained acceleration above the bias for releasing the firing pin to strike the primer and initiate airbag inflation.

United States Patent No. 4,580,810 discloses and claims an airbag system adapted to be mounted on the axis of a steering wheel of a vehicle wherein the sensor is mounted inside an inflator for the airbag. That system includes a gas generator having a housing, an inflatable airbag external to the housing, and ignitable gas-generating material contained in the

4,116,132, 4,167,276, 4,172,603, 4,161,228, and 4,204,703 disclose previous proposals generally illustrative of various crash sensor systems.

In general, previously proposed devices are often acceptable for their intended purposes, but they are not entirely satisfactory for a number of reasons, in particular because they do not always fire as rapidly as would be desired and cannot always distinguish between crashes in which inflation of the airbag is desirable and crashes in which inflation of the airbag is not desirable. There is continuing research in ways and means to accelerate such firing and improve the crash discrimination ability of the sensors.

The invention provides a safety restraint system for a vehicle, comprising a sensor, and means for mounting the sensor on the vehicle other than on the steering wheel and for mounting the sensor angularly wih respect to a horizontal plane.

The invention also provides a mechanical sensor with a low bias for mounting within a vehicle passenger compartment and operable without electrical power for igniting the pyrotechnic element of an airbag safety restraint system for the vehicle, the sneso comprising a sensor train which includes: a primer; a spring biased firing pin; and means responsive to sustain acceleration above a bias for firing pin to strike the primer; the sensor being mounted downwardly and angularly with respect to the horizontal axis of the

from 10 to 40 degrees with respect to the horizontal. A preferred range for the optimum angle of mounting is between 20 and 30 degrees. The exact optimum angle will vary from car to car and for different mounting locations and must be determined on a case-by-case basis.

Various forms of crash sensor system constructed in accordance with the present invention will now be described by way of example only with reference to the accompanying drawings, in which like reference characters identify the same or like parts, and in which:

Figure 1 is a cross-sectional view of a first form of crash sensor system with an electric switch sensor mounted at a 30 degree angle to the horizontal;

Figure 2 is an exploded perspective view of a mechanical sensor airbag system with certain parts broken away and removed;

Figure 3 is a side elevation view of a mechanical sensor with certain parts broken away and removed;

Figure 4 is a fragmentary view of a sensor similar to that shown in Figure 3 showing a sensing mass and a lever extending from a D-shaft before the movement of the mass incident to a crash;

Figure 5 is a partial sectional view of an electronic sensor with the sensing mass mounted at 20 degrees angle to the horizontal;

Figure 6 is a graph of the motions measured at the

placing a properly calibrated sensor at an angle permits discrimination between these two crashes.

Referring to the drawings, and initially to Figure 1, a first form of sensor 10 is mounted within a housing 11. The housing 11 is defined with one wall thereof constituting a bracket 13. As shown, the sensor is inclined at 30 degrees from a horizontal plane defined by the plane of the bracket 13, which is adapted to be installed on a vehicle.

Referring to Figure 2, an airbag safety restraint system 8 incorporating a second form of sensor 10 has the sensor mounted inside a gas-generator inflator 12. The inflator 12 is symmetrically mounted on a frame 14 to which is also mounted a housing or cover 16 for a folded airbag 18. The airbag housing or cover 16 is made of a frangible plastics material and encloses and protects the folded airbag 18 to prevent damage to the bag when it is stored in its uninflated condition.

The airbag safety restraint system 8 can be mounted through its frame 14 anywhere in the passenger compartment but at an angle between 10 and 40 degrees to the horizontal axis of the vehicle. This is done either by inclining the housing 16 downward within that angular range or by placing the sensor 10 obliquely within the housing 16 which then is secured by its frame 14 parallel to the horizontal axes of the vehicle.

The gas generator 12 includes a housing 32

airbag module is to be mounted and enters a lock pin hole in the sensor-initiator 10 when the airbag module is installed.

Each sensing mass 41 is associated with a pin 56 extending from a "D-shaft" (58' in the similar sensor shown in Figure 4). The other end of the pin 56 includes a spherical ball 60 in engagement with a helical biasing spring 62 (shown as spring 62' in Figure 4) to ensure the engagement of the pin 56 with its associated sensing mass 41 and to provide the proper bias against motion of the sensing mass. Each D-shaft 58 is provided with a suitable flat face formed in an otherwise generally cylindrical surface. In addition, a spring-biased firing pin 36 is placed in alignment with the primer 35 and is maintained in its retracted position by the cylindrically shaped portion of the D-shaft 58. The firing pin 36 is released when the flat face of the D-shaft 58 is aligned with the firing pin.

In Figure 4, a pure spring mass sensor is shown having an essentially undamped sensing means 41' which will usually travel a longer distance than an equivalent damped spring mass sensor. In all other respects, this sensor initiator is the same as sensor initiator 10 of Figure 3 and like numerals are used with accompanying primes for the corresponding parts.

It is also possible to use a damped spring mass sensor where the damping is created by a sharp edge

sensor on a downward angle is desirable.

A ball-in-tube crash sensor has one uncontrollable degree of freedom which is the location of the ball in the cylinder. If the ball goes down the centre of the cylinder without touching a side, then it will take a considerably larger velocity change for the ball to travel a given distance than if the ball is resting against the side. This is due to the fact that the air flow restriction is proportional to the 2.5 power of the clearance. If the clearance has a crescent shape such as would be the case when the ball is against the side of the cylinder, it can be demonstrated mathematically that the flow resistance is approximately half of the resistance when the clearance has a circular or ring shape. Moreover, if the ball is allowed to whirl around inside the tube, energy will be dissipated in the form of friction which will similarly downgrade the performance of the sensor particularly for marginal crashes. For car sensors, therefore, it is desirable to mount the sensors at an angle so that there is a predominant acceleration vector component holding the ball against one side of the cylinder.

In distinguishing between certain types of crashes which are characterised by long pulses, it has been found that vigorous crashes such as high speed car-to-car A-pillar impacts have a substantial vertical acceleration component, whereas non-vigorous crashes such as 9 mph (15 km/h) frontal barrier impacts, for

shown in Figure 10 at about 65 milliseconds for the A-pillar impact. It did not fire on the 9 mph barrier impact of Figure 11.

Figures 8 and 9 show the vertical accelerations for the same two crashes at the same location. Whereas the horizontal accelerations and velocities were very similar for these two cases, the vertical accelerations and velocities are markedly different. Thus, if the sensor was rotated so that it was sensitive to a portion of the vertical acceleration components as well as most of the horizontal acceleration components a sensor could be designed which would distinguish between these two crashes. This is illustrated in Figures 10 and 11, where the acceleration resolved about an axis at 24 degrees relative to a horizontal plane is shown. If these two plots are overlaid, one will note that the velocity curve for the 9 mph barrier impact is virtually unchanged, whereas the velocity curve for the A-pillar impact shows a marked oscillation. In fact, the A-pillar impact velocity curve is much steeper in the period from 50 to 75 milliseconds than is the velocity curve on the 9 mph impact.

Research by the inventor has shown that the sensor should be pointed downward, rather than angularly upward, to gain maximum improvement in firing response. Thus, the sensor fired in 65 milliseconds when rotated downward 24 degrees, but did not fire until 89

crash. And similarly, if the sensor is designed to fire on time for the A-Pillar crash it fires even earlier on the 9 mph crash.

However, when the sensor is placed on a 24 degree angle, the opposite occurs. A sensor can easily be designed which does not fire on the 9 mph crash but fires in plenty of time on the A-pillar crash. When a sensor is placed at a 24 degree angle as in Figures 10 and 11, it is sensitive to 41 percent (Sine 24^{o}) of the vertical velocity change and loses only 9 percent (1-Cos 24^{o}) of the horizontal velocity change. In the A-Pillar crash, there is a substantial oscillating vertical velocity change component. This, when superimposed on the longitudinal velocity change, causes the resultant to oscillate also. The sensor then fires on one of the peaks of the combined velocity change oscillation. On the 9 mph crash on the other hand, there is no such significant vertical velocity change and thus placing the sensor at an angle does not increase its sensitivity to this crash.

Although a passenger-compartment-mounted system has been described herein, it is obvious that many of the advantages of this invention would also apply to a crush-zone sensor system.

By indicating that the sensor is to be pointed downwardly, it is understood that it is the front, or part closest to the front of the vehicle, of the sensor that is meant.

horizontal acceleration components could be realised through the use of two accelerometers in an appropriate electronic circuit. The invention described herein relates to the use of the vertical acceleration components present in a vehicle crash to permit discrimination between crashes in which inflation of an airbag would be desired and crashes in which that would not be desired. Sensors have been placed on steering columns, and thus are more sensitive to the vertical acceleration components. The fact that that improved the discrimination ability and the response time of the sensor was not known, and thus all other crash sensors in the vehicle have always been placed with their sensitive axes in the horizontal plane.

5, wherein the sensor is mounted downwardly and angularly at an angle of about 10 to about 40 degrees from the horizontal.

7. A system as claimed in any one of claims 1 to 6, wherein the sensor is mounted downwardly and angularly at an angle of 10 to 30 degrees to the horizontal.

8. A mechanical sensor with a low bias for mounting within a vehicle passenger compartment and operable without electrical power for igniting the pyrotechnic element of an airbag safety restraint system for the vehicle, the sensor comprising a sensor train which includes: a primer; a spring biased firing pin; and means responsive to sustain acceleration above a bias for firing pin to strike the primer; the sensor being mounted downwardly and angularly with respect to the horizontal axis of the vehicle.

9. A safety restraint system for a vehicle containing an electronic sensor comprising a sensing mass; and means responsive to the motion of the sensing mass; the said sensing mass being sensitive to vertical as well as horizontal acceleration components.

10. A system as claimed in claim 9, wherein the response means utilizes strain gauges.

11. A system as claimed in claim 9, wherein the response means comprises a piezoelectric crystal.

12. A safety restraint system for a vehicle comprising a non-steering-wheel-mounted sensor having

restraint system comprising a non-steering-column-mounted sensor responsive to a component of acceleration parallel to an axis that is oblique to the horizontal plane of the vehicle.

21. A vehicle as claimed in claim 20, wherein the said axis lies substantially in a fore-and-aft vertical plane of the vehicle.

22. A vehicle as claimed in claim 21, wherein the said axis slopes downwards towards the front of the vehicle.

23. A vehicle as claimed in any one of claims 20 to 22, wherein the said axis is at an angle in the range of from 10° to 40°, preferably, from 20° to 30°, to the said horizontal plane.

24. A vehicle as claimed in any one of claims 20 to 23, wherein the or at least one said safety restraint system is as claimed in any one of claims 1 to 7, claims 9 to 14, and claims 16 to 18.